



# Rediscovering the microbial composition and dynamics of the annual phytoplankton spring bloom in the North Atlantic

Luis M Bolaños<sup>1</sup>, Susanne Menden-Deuer<sup>2</sup>, Lee Karp-Boss<sup>3</sup>, Françoise Morison<sup>2</sup>, Chang Jae Choi<sup>4</sup>, Alexandra Z Worden<sup>4</sup>, Jason Graff<sup>5</sup>, Nils Haëntjens<sup>3</sup>, Toby K Westberry<sup>5</sup>, Alison P Chase<sup>3</sup>, James G Allen<sup>6</sup>, Peter Gaube<sup>7</sup>, Consuelo Carbonell-Moore<sup>5</sup>, Emmanuel Boss<sup>3</sup>, Michael Behrenfeld<sup>5</sup>, Stephen J Giovannoni<sup>1\*</sup>

1 Oregon State University, Department of Microbiology, Corvallis, OR, USA, 2 University of Rhode Island, Graduate School of Oceanography, Narragansett, RI, United States, 3 University of Maine, School of Marine Sciences, Orono, ME, USA, 4 Monterey Bay Aquarium Research Institute, Monterey, CA, USA, 5 Oregon State University, Department of Botany & Plant Pathology, Corvallis, OR, USA, 6 University of California, Earth Research Institute, Santa Barbara, CA, USA, 7 Applied Physics Laboratory, University of Washington, Seattle, WA, USA

\*Corresponding author

Spring phytoplankton blooms are massive events in high-latitude oceans. As blossoms on land signal the end of the winter and the conditions for reproduction, in the ocean a similar phenomenon takes place. Transition between winter and spring in the oceans creates a set of conditions that favors high phytoplankton division rates (reproduction) and microscopic algae start to accumulate because grazers are unable to catch up with the outburst. Required conditions for the phytoplankton bloom include sunlight, nutrients brought from below, as water warms and stratifies, and atmospheric carbon dioxide (CO<sub>2</sub>). When phytoplankton dies or is consumed by grazers, a big fraction of the organic matter (including the carbon removed from the atmosphere) sinks to the deep ocean. These enormous biological pulses in the ocean, specially in the North Atlantic, contribute greatly to the sequestration of atmospheric carbon into the ocean (biological pump) and are key players in global carbon dynamics.

Diatoms have been recognized as the dominant taxa of spring blooms in the North Atlantic with few species dominating the blooms in their highest productivity stages. Diatoms have a wide size range, from 2 to 500 µm, and it is estimated that there are between 20,000 to 2 million species. Blooming diatoms are mostly big size (10 to 100 µm) with a high amount of silicates, which they use to build frustules or cell walls. Diatom features are highly relevant for carbon dynamics, bigger and heavier cells sink faster and make more efficient the carbon sequestration and exportation to the deep ocean.

Few field campaigns have been done addressing the dynamics of the microbial composition. Furthermore, most of the campaigns have been done in the eastern North Atlantic and knowledge extrapolated to the whole ocean. Even though, the North Atlantic is highly heterogeneous, new studies have shown patchiness in biomass, community composition and bloom initiation timing.

As part of The North Atlantic Aerosols and Marine Ecosystems Study (NAAMES), an interdisciplinary investigation and the first Earth Venture Suborbital (EVS) NASA mission focused on marine ecosystems, we collected field data in the eastern North Atlantic for four years targeting a different stage of the annual dynamics of the bloom each year.

Using complementary techniques as DNA sequencing high-throughput imaging and flow cytometry, among others, we generated 4 datasets: early winter (bloom initiation), early spring (accumulation phase), late spring (climax transition), and fall (early depletion phase).

Our most recent results showed a shift in the microbial composition from cyanobacteria and pico-eukaryotes dominating in winter to a diverse eukaryotic spring bloom. In a regional scale, we found an outstanding difference between subpolar and subtropical communities, specially in spring where pico-eukaryotes dominated the subtropical stations while nano- and micro eukaryotes were dominant in subpolar regions. High chlorophyll concentrations in spring correlate with the presence of bigger cells (diatoms or haptophytes) and showed a north to south gradient of surface concentrations, reflecting the dynamics and timing for different latitudes. Around half of the defined set of eukaryotes found in the late spring of both regions can be traced genetically to winter, suggesting an overwintering strategy and further blooming.

Our results indicate a more complex microbial community composition and dynamics than previously thought. Even though, it remains to be determine if this is a consequence of the lack of previous field sampling, east-west North Atlantic physical differences, or the warming of the ocean during the last decades which can favor the decline of bigger cells and the appearance of pico-size organisms. The characterization of the community composition at different locations and stages of the North Atlantic phytoplankton bloom annual cycle is a cornerstone to address the impact of this ecosystem to the global ocean and atmosphere.

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